MACKENZIE BASIN IMPACT STUDY FINAL REPORT

Summary of Results

Environment Canada
Environnement Canada

Canada

Eric Leinberger, *University of British Columbia*

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ADDITIONAL CONTRIBUTORS TO COMPONENT STUDIES

Natural Science and Engineering Research Council (NSERC)
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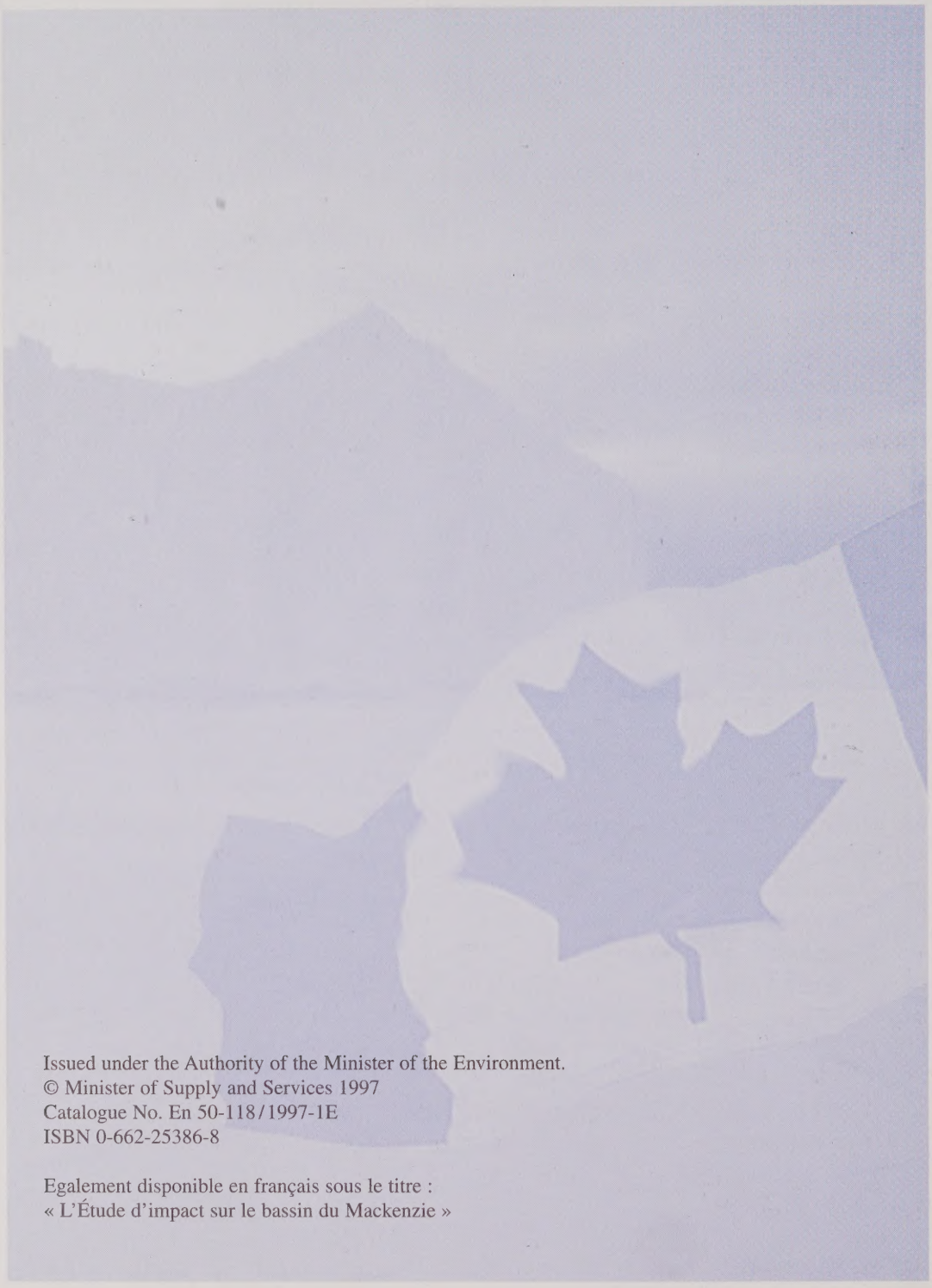

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1. INTRODUCTION

1.1 Objectives

This is the Final Report of the Mackenzie Basin Impact Study (MBIS), a six-year collaborative research project which began in 1990 and was supported by the Canadian government, Northwest Territories government, B.C. Hydro, the University of Victoria, Esso Resources Ltd. and others. The purpose of the study was to look at the effect which a change in climate might have on the Mackenzie Basin, its lands, waters, and the communities that depend on them.

The story of the study starts in 1988. At the Changing Atmosphere Conference in Toronto, scientists warned the world's governments about the potential for a change in climate because of the increasing concentrations of carbon dioxide and other greenhouse gases. At the time, the Canadian government had just completed its first environmental action plan (Green Plan). It included a three-pronged strategy to deal with climate change:

- to promote the limitation of greenhouse gas emissions;
- to support research on the processes and effects of climate change;
- to understand the repercussions of the research results on government policy.

The timeliness of the study was underlined at the Earth Summit in Rio de Janeiro in 1992 when Canada signed the Framework Convention on Climate Change. It committed the country to stabilizing greenhouse gas emissions at 1990 levels by the year 2000. Four years later, in the spring of 1996 the Intergovernmental Panel on Climate Change, which was established by the United Nations, concluded that recent variations in the climate could not be due to natural forces alone. The panel said that continued increases in concentrations of carbon dioxide and other greenhouse gases would lead to a warming of the world's climate.

The Mackenzie Basin was one of three areas in Canada which the scientific community selected for a detailed study. The other two areas were the Prairies and the Great Lakes - St. Lawrence River Basin.

The Mackenzie Basin was chosen for a case study in order to look at a high latitude or northern region which had sensitive ecosystems and a large number of aboriginal people who were still following the traditional ways or lifestyle. The question was: how would an economy which was based on natural resources and a Northern culture cope with climate warming? How could they deal with the changes which were expected to be the most significant in the world?

Indeed, there are signs that the climate has warmed up in the Mackenzie Basin. This area, which includes parts of the Yukon and Northwest Territories as well as northern British Columbia, Alberta and Saskatchewan, has experienced a warming trend of 1.5°C this century. Scenarios of climate change, based on experimental results from General Circulation Models of the atmosphere, suggest that this region could warm up by 4°C to 5°C between the 30-year base-line period of 1951-1980 and the middle of the 21st century.

This report is directed to governments, communities, researchers and the private sector and all those individuals or organizations with an interest in climate change in this region. The report outlines the potential damage identified during the course of the study and provides recommendations for future action.

1.2 Four Key Findings

Despite the enormity of the task, the years of research and the hours of sometimes animated discussion, it is possible to distill four points or key findings from the study.

1. Effect on the land - Most of the regional effects of climate warming scenarios are not positive. They include lower minimum water levels in the region's waterways and increased erosion from thawing permafrost, as well as a rise in the number of forest fires and landslides and a reduction in the yields of forests. These will probably offset any potential benefits from a longer growing season. Some of these changes have been observed during the recent 35-year warming trend.

2. Effect on communities - Most participating stakeholders said the region can adapt if the changes occur slowly. But, if the area warms up quickly, adapting will be considerably more difficult. If vegetation and wildlife patterns are modified by climate change, then traditional aboriginal lifestyles could be at risk. The effect of long-term climate change on communities, however, will also be determined by other factors, including lifestyle choices made by the region's inhabitants. Stakeholders did not know what role climate change would play in the future of the region's two economies — the wage economy typical of southern Canada and the non-wage economy of the traditional lifestyle.

3. Role of regional stakeholders - Increased local and regional control of land and water resources will help to reduce the area's vulnerability and help local residents adapt to climate change. That, however, may not be enough to respond effectively to global warming. Similarly, reducing regional emissions will not be enough to prevent the climate from changing. If the governments which signed the convention on climate change fail to slow down the change in climate, then regional stakeholders may need to intervene at national and international levels to warn others about the consequences to the Mackenzie Basin.

4. Role of the integration process - The effect of a change of climate on the Mackenzie Basin is more than the sum of changes to the trees, wheat, water and permafrost. Governments, communities, industries and people will respond to the combined effects of climate change on water and land resources. These responses will be tempered and shaded by the choices government officials, community residents and industry leaders make in response to other issues such as the demands of the global economy, traditional lifestyles and political realities. Computer-based models are one way to bring together or integrate many parts of the whole, but these models are limited in their abilities to describe how regions and people relate to climate change and other stresses. The experience of MBIS suggests that an integrated assessment requires a partnership of stakeholders and scientists, in which visions are shared and respected, and information is freely exchanged.

1.3 Next Steps

Researchers and stakeholders made a number of recommendations including:

- governments to include climate change in water, forest and other management agreements for natural resources as well as to encourage and support community-based monitoring and archiving programs;
- communities to reduce greenhouse gas emissions, participate in monitoring programs and support training on adapting to climate change;
- private sector industries such as forestry, transportation, mining, construction and oil and gas to include climate change in research, planning and design of projects such as pipelines, dams and tailing ponds;
- researchers to incorporate traditional knowledge into data bases, to consider scenarios beyond the doubling of greenhouse gas concentrations, to use regional institutions for co-ordinating monitoring and archiving, and to provide reports in plain English.

1.4 Notes about the Study

One of the more interesting aspects of the study was that scientists from many disciplines and stakeholders from the region worked on it together. Not surprisingly there were problems. When the study began in 1990, it was difficult to get regional governments, aboriginal communities and private sector industries actively involved. But their interest and participation increased over the next few years.

In addition, there were technical problems such as incompatible data bases. And there were logistical problems. Canada is a large country and getting people together was a challenge. This type of collaboration required considerable effort and good will to succeed. But on the whole, this unique approach to an integrated assessment worked.

During the study, scientists and stakeholders freely shared information across cultures and disciplines and learned much from each other. The hope is that this sharing will continue long after the report is published and that this model will prove useful for similar studies in other areas of the world.

For their part, scientists took information about the temperature and precipitation from models of future climate change and used this data to construct climate scenarios for other models such as those dealing with ground temperatures, the rate of growth in forests and the water levels in rivers and lakes. The point was to discover what would happen to waterways, permafrost and animal and fish habitats as well as to communities, industries and traditional lifestyles if the climate changes.

The stakeholders, who included representatives from aboriginal organizations, colleges, institutes, industries and all levels of government, wrestled with questions such as: What if the world becomes warmer because of increasing concentrations of greenhouse gases? What would the regional effects of warming be? What could happen that might be considered dangerous? Would it make a difference to our future, and that of our children? How could people living in the regions and countries prepare for or avoid these changes?

These questions formed the basis of many of the discussions during the study. The "what if?" question posed by science provided the scenario of the effects of climate change. The stakeholders' response to the "so what" question reflected their views of the significance of the scenario to their daily lives. The stakeholders' replies to the "what should be done?" question ranged from reactive to proactive. This last question was a hard one which defied simple answers, and which was further complicated because of its link to the challenge of sustaining the ecosystems and communities in this region, and elsewhere. All the discussions centered on five themes:

- interjurisdictional water management;
- sustainability of ecosystems;
- economic development;
- maintenance of infrastructure;
- sustainability of aboriginal lifestyles.

1.5 The Report and its Contributors

The report contains a summary of the proceedings of the MBIS Final Workshop, held May 5-8, 1996, in Yellowknife. More than 100 people attended, including researchers and stakeholders from the study area and other parts of Canada as well as scientists from the United States, Europe and Australia.

The full report - The full proceedings are published separately as the MBIS Final Report. This is a large technical document containing:

- summaries of climate impact assessments of land, waterways, forests, animals, economy and communities;
- condensed versions of the round-table discussions with regional stakeholders;
- contributions from studies conducted in other countries;
- statements from government representatives.

The appendices include reprints of summaries from the first and second MBIS Interim Reports, (which were published in 1993 and 1994 respectively) prepared statements by some of the round table panelists, a list of contract reports and acknowledgments.

Table 1 lists the lead investigators who participated in and contributed to the study. Most projects involved two or more researchers. Some of these scientists as well as a number of stakeholders also participated in other studies taking place at the same time in the region, including the Northern River Basins Study, Peace Athabasca Delta Technical Studies, and Global Energy and Water Cycle Experiment. The discussions in the study benefited greatly from the experience the scientists had on other research programs.

If the region's climate continues to warm up, water and land resources would be affected. Some scenario results are a continuation of the changes which are taking place during the current warming trend. The rate of change in the scenarios may be quite different from current trends, but it is difficult to work out how quickly these changes would occur.

Table 1. MBIS Participants and Contributors

LEAD INVESTIGATOR/ AGENCY	TOPIC	DURATION	MBIS SUPPORT ($ 000)	OTHER IN-KIND & FINANCIAL SUPPORT
Aharonian (U. Victoria)	Climate-society interactions, Aklavik	1992-94	0	U. Victoria, Aklavik
Anderson (McMaster U.)	Petroleum production	1993-96	42	
Andres (Alberta Res. Council[1])	Peace River ice	1991-94	50	Alberta Research Council
Bayley (U. Alberta)	Peatlands	1991-96	84	NSERC[2], Env. Canada, Esso Ltd.
Benton (Pacific Forestry Centre[3])	Forestry: growth and yield, fire, pests.	1992-96	50	B.C. Ministry of Forests
Bielawski (Arctic Inst. Of N.A.)	Traditional knowledge, Lutsel k'e (pre-proposal)	1992-94	22	Lutsel k'e
Bone (U. Saskatchewan)	a) Settlements, b) Non-renewable resources	1993-96	38	
Brklacich (Carleton U.)	Agriculture	1992-96	81	Agriculture Canada
Chin (BC Hydro)	Williston Lake runoff	1992-94	0	BC Hydro
Cohen (AES[4] & UBC)	MBIS Framework	1989-96	0	Env. Canada, UBC
Felton (Env. Canada)	Water management	1993-94	0	Env. Canada
Geol. Survey of Canada[3]	Permafrost	1991-96	65	Nat. Res. Canada
Gong (U. Calgary[5])	Remote sensing, land	1992-94	20	
Gratto-Trevor (CWS[4])	Mackenzie Delta shorebirds	1992-95	30	Env. Canada
Huang (BCRI[6])	Multi-objective model	1994-96	0	Env. Canada
Kerr (Env. Canada)	Water levels and flows	1993-96	0	Env. Canada, GEWEX[7]
Latour (CWS[4] & NWT Renew. Resources)	Wildlife response to burns	1991-94	28	NWT Renewable Resources
Lonergan (U. Victoria)	Resource accounting, socio-economic scenarios	1991-95	87	U. Victoria, Esso Ltd.
Lonergan (U. Victoria)	Two economies, Wrigley	1994-96	35	Env. Innovation Program, Pedzeh Ki
Maarouf (AES[4])	Geese	1993-96	0	AES[4] & CWS[4]
Majorowicz[9]	Ground temperatures	1995-96	0	Env. Canada
Melville (Sask. Research Council)	Thermal habitat for freshwater fish	1992-95	40	Sask. Research Council
Newton (U. Toronto)	Community response to floods	1992-94	08	Emerg. Prep. Canada, Aklavik, Fort Liard
Rothman (AES[4] & UBC)	Forest economics	1995-96	0	Env. Canada, UBC
Smith (AES[4])	Climate change scenarios	1991-93	0	Env. Canada
Soulis (U. Waterloo)	Basin runoff	1992-94	30	GEWEX[7]
Wall (U. Waterloo)	Tourism	1991-95	25	Tourism Canada
Wein (U. Alberta)	Veg. response to fire	1991-94	10	NSERC[2]
Welch (DFO[8])	Fisheries data base	1991-93	24	U. Manitoba, DFO[8]
Yin (AES[4] & UBC)	Land assessment	1992-96	0	Env. Canada, UBC
6-YEAR TOTAL			769	

Notes: 1=now at Trillium Engineering, Edmonton, 2=Natural Science & Engineering Research Council, 3=Natural Resources Canada, 4=Atmospheric Env. Service (AES) or Canadian Wildlife Service (CWS), Env. Canada, 5=now at U. California-Berkeley, 6= BC Research Institute, now at U. Regina, 7=Global Energy & Water Cycle Experiment, 8=Dept. of Fisheries & Oceans, 9=Northern Geothermal, Edmonton.

2. RESEARCH RESULTS

2.1 Natural Resources

2.1.1 Water

Results of a study of the whole basin by *Soulis et al. (University of Waterloo, from MBIS Interim Report #2)* show that if the climate changes, the runoff of water from rain or melted snow which flows into streams, rivers and lakes would drop by seven per cent, though some areas within the basin could be wetter. For example, Chin and Assaf *(BC Hydro, from MBIS Interim Report #2)* projected a six per cent increase in runoff for the Williston Lake region of northeast British Columbia.

Using information from *Soulis et al.* , other studies from the Global Energy and Water Cycle Experiment, and a model of the rivers and lakes of the lower Mackenzie River, *Kerr (Environment Canada)* developed a scenario of changes in levels and flows for the river and Great Slave and Great Bear lakes. His results show that levels and flows would be lower during the fall and winter months, and that the annual minimum levels would be lower than the extremely low levels observed in 1995. The reason for this is that the increase in the rate of evaporation would offset any increase in precipitation.

One other point, according to a study by *Andres (Trillium Engineering, from MBIS Interim Report #2)*, the ice season on the Peace River would be about a month shorter.

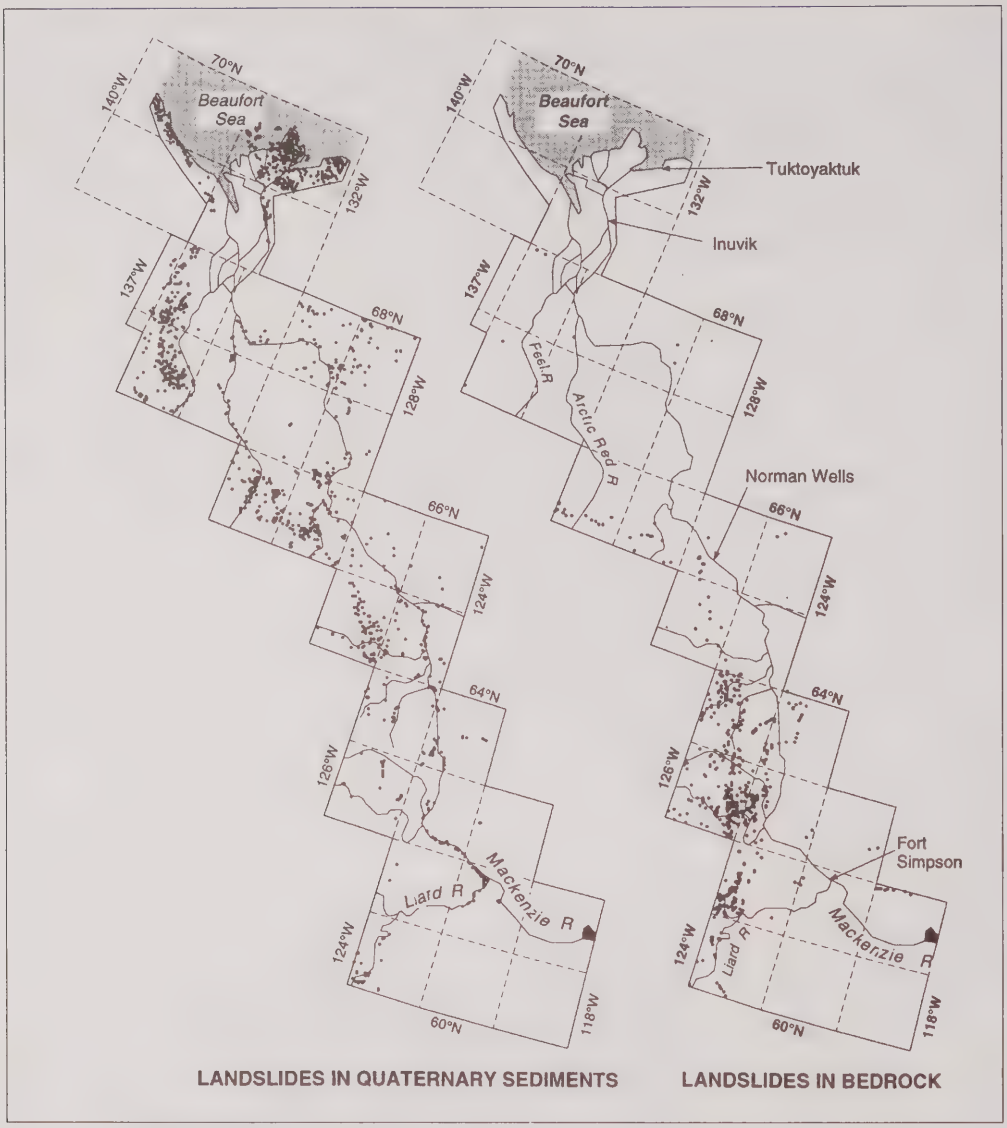
2.1.2 Land

Landslides - *Aylsworth and Duk-Rodkin (Natural Resources Canada)* provided an inventory of 3,400 landslides in the Mackenzie Valley and Beaufort Sea coastal region. Many of these occurred in areas with sedimentary rock that contained large amounts of ice. Heavy rainfall and forest fires triggered some landslides. Along the Beaufort Sea coast, storm surges contributed to the erosion of the coast. What happened was that the action of the waves pounding against the rock exposed the ice-filled sediments which then melted during the summer. In some areas, the coast line has eroded by more than one metre a year.

Permafrost - Using a ground temperature model, *Dyke et al. (Natural Resources Canada)* showed that in the discontinuous zone (where some unfrozen ground exists), the permafrost would become thinner, and disappear altogether in some areas along the southern margin of the region — such as in the area of Fort Simpson in NWT. In the continuous zone (where all sites contain permafrost), the active layer or the thin layer on top which thaws each summer would grow only slightly. The model did not include the indirect effects resulting from changes in the number of forest fires, heavy rains or storm surges.

Aerial view of landslide near Tuktoyaktuk in the Northwest Territories. The landslide was triggered by a storm surge in the Beaufort Sea several years earlier. Cliff wall is 20 to 30 metres high. (Photo by J.M. Aylsworth, Geological Survey of Canada, Natural Resources Canada)

Landslide triggered by a forest fire. The heat melted the ice in the ground causing a landslide. (Photo by L.D. Dyke, Geological Survey of Canada, Natural Resources Canada)

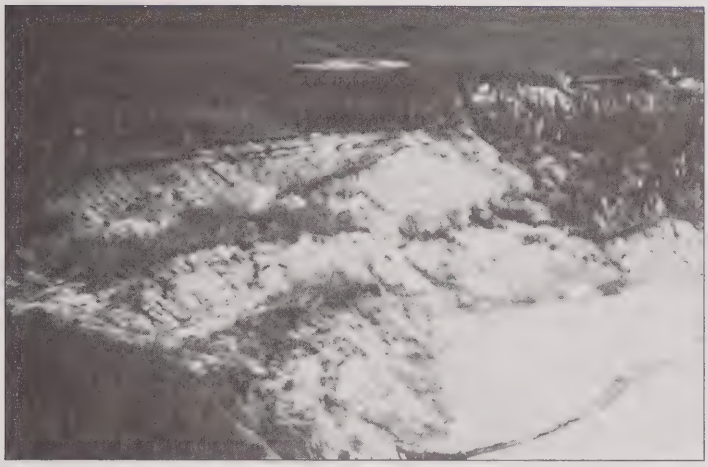


Landslide sites in Mackenzie Valley and Beaufort Sea coastal zone. Quaternary sediments are fragments of rock laid down by rivers, wind, ice and the sea. (Source: J.M. Aylsworth)

Farther south in Alberta, *Majorowicz and Skinner (Northern Geothermal and Environment Canada)* have documented that ground surface temperatures have risen faster than air temperatures in much of the province.

Vegetation - Changes in vegetation could occur for a number of reasons, including more insects and forest fires as well as longer growing seasons. *Hartley and Marshall (Hartley Forest Consultants and University of British Columbia)* developed the Mackenzie Basin Forest Productivity Model for areas of commercial timber. These are located primarily in southeastern Yukon and northern British Columbia and Alberta. The model was applied to a scenario of climate warming, including a fire scenario developed by *Kadonaga (University of Victoria)*. The fire scenario was based on computations of the Fire Weather Index (a measure of the weather and forest conditions which are important to fire) for scenarios of climate warming. In each scenario, the Fire Weather Index increased.

The results suggested that without changes in fire management, the number and severity of forest fires in the area would increase and the average number of hectares which burned annually would double. And even though the rate of growth of hardwood trees would improve, a larger percentage of softwood trees would die each year as the direct result of a warmer climate. Further, when the fire scenario was factored in, the average age of the trees declined and the yields from all stands of commercial timber — softwoods and hardwoods — fell by 50 per cent.



A large landslide 90 kilometres west of Norman Wells, Northwest Territories. (Photo by P.A. Egginton, Geological Survey of Canada, Natural Resources Canada)

Peatlands - Another way that warming might affect vegetation is through changing water levels and water tables. *Nicholson et al. (University of Alberta and Connecticut State University)* developed a peatland growth model, with a classification of seven types based on such characteristics as air temperature and height of vegetation above the water line. If none of these types applied to a particular site, it was classified as absent of peatlands. When this classification system was applied to scenarios of climate warming, this absent category expanded to include all sites south of 60 N and the water table declined by 10 to 50 centimeters. Farther north, the number of peatland sites increased from Norman Wells to the Beaufort Sea coast, with water tables increasing by 10 to 30 centimeters in some areas. The drying of the south parallels the scenario of the increasing number of fires and falling water levels, which was described above by other studies that used the same scenarios but very different analytical techniques.

Closeup along one block of the landslide west of Norman Wells. (Photo by L.D. Dyke, Geological Survey of Canada, Natural Resources Canada)

Projected changes in water table, in tens of centimetres. (Nicholson et al.).

Warmer temperatures could also result in a change in the insect population. Insects which are now common to southern Canada would move into the Mackenzie Basin region. Similarly, the pests which are in the region today would move not only father north but also to higher elevations. *Sieben et al. (University of British Columbia)* showed that according to one warming scenario, the number of hectares which would become susceptible to the white pine weevil would more than double to include all of the forested area. The weevil, a southern pest at present, slows down forest regeneration.

2.1.3 Wildlife

Changes in climate, vegetation and water would affect the region's wildlife at various stages of their life cycles, including migration and reproduction. Relationships between animals and the landscape are complex, and for many species, the effect of climate change was difficult to project.

Fish - *Melville (Saskatchewan Research Council)* reported that lake temperatures would rise if the climate warmed up, but from the

information currently available could not determine what effect that would have on fish habitats in freshwater. Cold water species (fish that prefer cold water) might be at a greater risk, but questions remain about their potential to adapt.

Furbearing animals - Furbearing animals might be affected by a rise in the number of forest fires. *Latour and Maclean (Environment Canada and NWT Renewable Resources)* have shown that the number of lynx and marten may decline while red foxes may benefit. Reports from aboriginal communities suggest that the lower water levels in the Peace-Athabasca delta have reduced the muskrat population.

Caribou - The effect on caribou appears to be more pronounced. Using a model developed originally for the Porcupine caribou herd, *Brotton et al. (University of Waterloo)* suggested that the caribou in the Bathurst herd, which lives north of Great Slave Lake, would probably lose weight, in part because of the heavier snow cover, and in part because of an increase in the number of insects harassing the herd — a result of warmer summer temperatures.

Birds - Studies of birds were hampered by the complexity of their lifecycles and the varying landscapes along their lengthy migration routes. Because these routes are outside the Mackenzie region, the studies could only assess the effect climate change might have on birds' summer habitats. *Gratto - Trevor (Environment Canada)* reported that the summer habitat of shorebirds found in the Mackenzie Delta probably would not change much. *Maarouf and Boyd (Environment Canada)* said that warmer spring and summer temperatures would be favourable for geese, but permafrost thaw and increased fire frequency would damage habitat.

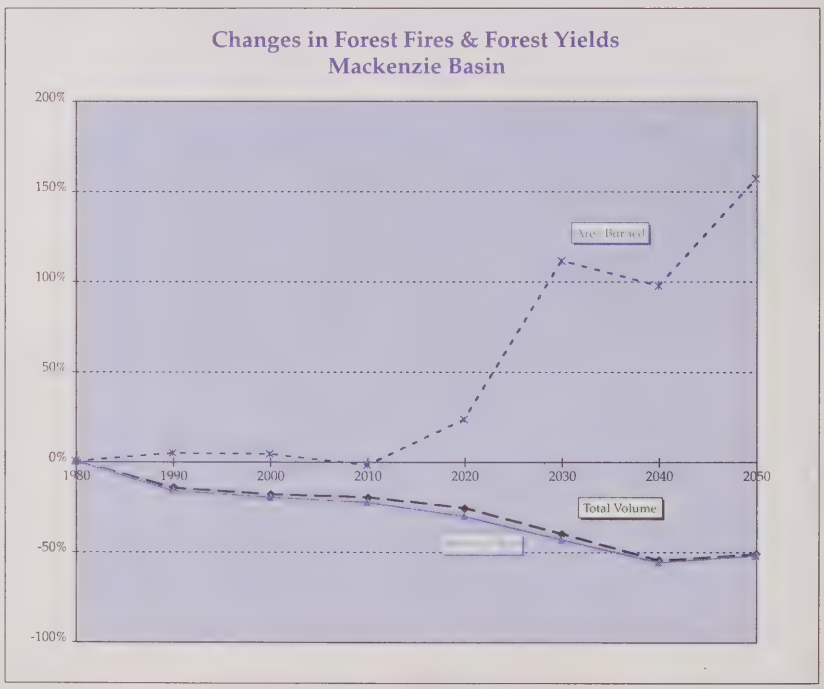
These studies provide a western, science-based picture of the reaction of the area's wildlife to a change in the environment. Traditional knowledge could fill in some of the missing details. MBIS attempted to do a case study of Lutsel k'e, a community on the east side of Great Slave Lake. *Bielawski (Arctic Institute of North America, from MBIS Interim Report #2)* provided some information. Unfortunately, full financial support for this study was not available and the opportunity for important collaborative research was lost.

Western science and traditional knowledge could become partners in exploring the potential effects of climate warming on wildlife. The potential of such a partnership was discussed at length during the Round Tables (See Section 3).

2.2 Industry and Communities

2.2.1 Industry

In general, a change in climate would be a mixed blessing for industry. Such a change could reduce forest yields, thereby increasing the risks for commercial forestry in northern Alberta and British Columbia *(Rothman and Herbert, Environment Canada and University of British Columbia)*. Agriculture, on the other hand, could benefit from the longer growing season, but farmers would have to expand their irrigation systems to keep their farms afloat (*Brklacich, Carleton University*).



The projected changes in the area burned, the average age of trees, and the total volume of available timber (Source: Rothman and Herbert)

There were two case studies on the effects which climate change might have on tourism. Only minor changes are projected for canoeing, boating, camping, etc. in Nahanni National Park in southwestern NWT, but sport hunting could be hurt because of the losses in the Bathurst caribou herd. *(Brotton et al., University of Waterloo)*.

Offshore energy development in the Beaufort Sea could benefit from the longer summer, but increased coastal erosion and storm surges would lead to higher costs and environmental risks *(Anderson et al., McMaster University)*.

2.2.2 Communities

Northern residents who live in small communities see more of the changes in the environment than government officials tucked away in office towers. Moreover, community residents use information differently. For example, reports from northerners and southerners about changes in the environment reflect different visions of the effect which climate change may have for traditional and wage-based lifestyles. To integrate western science and traditional knowledge is possible (and greatly to be desired), but only if researchers make a real attempt to understand and connect with the lives of the people in this area. *(Bielawski, Arctic Institute of North America, from Interim Report #2)*

Some possible effects - Climate change scenarios suggest that although there might be fewer floods in the spring, a warmer climate could create other problems. For instance:

- lower water levels in the region's lakes and rivers would make navigating them more difficult. (*Kerr, Environment Canada*);
- the risk of landslides and ground subsidence from thawing permafrost would increase for some NWT communities; *(Bone et al., University of Saskatchewan)*;
- the winter road season in northern Alberta would be shorter; *(Andres, Trillium Engineering, from MBIS Interim Report #2)*;
- there would be more forest fires. *(Kadonaga, University of Victoria)*.

How well a community responds to a change in climate will depend on the area's social, economic and geographic situation, as well as on the residents' previous experience with severe weather and long-term variations in climate. For example, *Newton (Newton Assoc.)* studied how people in two communities coped with recent flooding. One community, Fort Liard, had easy access to higher ground, while the other, Aklavik, was situated in the middle of the Mackenzie Delta. When Fort Liard was flooded, residents moved to community buildings or friends' houses on higher ground. When Aklavik was flooded, residents could not get away as easily because there was no high ground. Instead they helped each other — evacuating elderly and disabled residents by aircraft. Results of the study also showed that how individuals responded was different in each case.

Interestingly, Fort Liard had a more difficult time and suffered greater damage from the flood than Aklavik. That was because Fort Liard had not been flooded as many times as Aklavik and so had fewer and less well-defined support services in place. Not surprisingly, Fort Liard required a broad range of support from different levels of government.

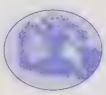
As Northern communities grow and change, response to flooding and other hazards will also change. The story of the two communities may be instructive when thinking about how Northerners might cope with a change in climate.

Similarly, a change in climate would affect a community which depended on the traditional lifestyle of hunting, trapping and fishing differently than a community which depended on a nearby mine or oil or gas operation. For example, the second community would have much more infrastructure at stake if the permafrost on which all that rested started to thaw.

But climate change is more than a problem of engineering. Climate change may also pose social questions because it may affect the balance of the wage economy and non-wage traditional economy. For example, with a change in climate, a gradual warming might lead to new wage paying jobs in farming and offshore energy projects *(Lonergan et al., University of Victoria)*. But the same scenario might also pose new risks for transportation, forestry and mining, as well as alter the conditions for hunting, trapping and fishing significantly. These activities would also be influenced by land claims and external economic pressures, such as national and international demand for the region's natural resources. (Land claims are claims by aboriginal people for ownership of the land.) MBIS has just scratched the surface of how all these pressures would affect the wage and non-wage economies of northwest Canada.

2.2.3 Integrated assessment or getting it together

One of the more interesting features of the MBIS was that it was an integrated assessment of climate change scenarios. This meant that scientists shared information, experiences, results and models at workshops and in conversation with each other and with stakeholders.



All participants used climate warming scenarios developed for the study. Successful examples of cross-disciplinary collaboration include:

- the levels and flows study and the tourism study applied the basin runoff scenario;
- the forest yield, forest industry and furbearing animals studies used the forest fire scenario;
- the settlement development study used the data of the permafrost study to assess risk;
- the energy study applied permafrost, ice and water level scenarios.

There were also three modelling exercises that looked at the indirect implications of these many changes on the region. These studies used information from other studies and data for their computer-based mathematical models.

In one study, *Yin (Environment Canada and University of British Columbia)* focused on agriculture and forestry. The model, called a land assessment model, used information about the effect a change of climate would have on those two industries and the goals their representatives had for them. The point was to answer the question: Will there be new conflicts over land use? Results showed that as the climate warmed up and more land was turned over to agriculture, the loss of top soil from erosion would exceed the target set for soil erosion. Also, not enough spruce would grow to fill the needs of the forestry industry. The model has limitations, however, since fisheries, wildlife and some other activities were not addressed. The model can be run using other scenarios if additional data can be obtained.

Huang (University of Regina) took a slightly different approach to the same question. This study developed a multi-objective programming model to discover whether or not the ambitions of various stakeholders could be met if there was a change in climate. Four scenarios were considered. The first two scenarios looked at what would happen if the agriculture and commercial forestry industries grew slowly or grew quickly. The third and fourth scenarios looked at what would happen if the agriculture industry took over some forest land or large tracts of forest land. The last two scenarios were included as a response to the decline in forest yield projected *by Hartley and Marshall.*

In all four scenarios, the agricultural industry could expand and stay within constraints imposed by other users of the region's resources. In the last two scenarios, however, the forestry industry would decline. This model could be tested with other scenarios.

Lonergan et al. (University of Victoria) developed an economic model and applied it to a scenario of expansion in oil production in the Beaufort Sea, based on *Anderson et al.* The point was to discover if the job picture would change. These results were then combined with a survey of the Pedzeh Ki First Nation in Wrigley, NWT. The results of Lonergan's study suggested that short-term wage employment would increase in the community business and personal services sector. The question was would these jobs be in town or out of town? Would residents be able to live and work in their community or would they have to commute to distant jobs often leaving for days or weeks on end? The authors were concerned that the community could be disrupted if the job opportunities went outside.

The implication for lifestyles of aboriginal people could not be determined, in part, because of the many unsettled land claims. Also other changes such as the thawing of the permafrost and changes to forestry were not addressed. This issue requires considerably more research.

All of these studies, including the modelling exercises, were able to use the results of other MBIS studies and contributed activities. This suggests that integration was at least partially achieved. The final workshop provided a forum for stakeholders and scientists to exchange information across disciplines and cultures. In short the workshop was a shared learning experience of the region's sensitivity to climate change.

That said, however, there were a number of opportunities which were missed. They included:

- traditional knowledge could not be included in any of the quantitative models;
- the hydrologic scenario — water levels and flows — was not completed until late in the study, too late for many MBIS projects;
- the resource accounting study could not consider forestry, agriculture, wildlife or permafrost because the data was not compatible;
- results from the study on forest pests were not available until after the forest yield study was finished.

Most of these problems reflect the difficulty in co-ordinating timing of the results of research, and in transferring data between scientists.

The decision to proceed with this large set of scenarios, studies and modelling exercises was taken because there was no consensus within the community about the best way to do an integrated assessment. MBIS became an experiment in which different methods were used, with the hope that each would produce information that would be valuable to stakeholders, and ultimately to the debate about responses to climate change.

2.3 Review of MBIS by University of Texas

Dyer and Stewart (University of Texas, Austin) examined the research and consultation process within MBIS, as part of their review of sustainable development case studies from several countries. Although MBIS did not directly concern planned economic developments, the authors included it because they said its processes, such as stakeholder involvement and asking "what if" questions were consistent with successful sustainable development.

The authors said that while most stakeholders supported the study's process — which has received international interest — some aboriginal participants had raised important concerns such as whether or not aboriginal or traditional knowledge had been given the same weight as outside or scientific knowledge. These participants also felt that there was not enough direct contact with local stakeholders and that the study's research agenda was too rigid.

Overall, however, the study's process was seen as open-ended and participatory, and that it got people accustomed to the idea that "global warming" was their problem. Their suggestions for improving the process were consistent with those expressed during the MBIS Final Workshop round tables (see Section 3).

2.4 Other Canadian and International Contributions

Fassnacht (University of Waterloo) described a new method for estimating the amount of time suspended sediments took to travel through stream channels in the Mackenzie Delta. *Gan (University of Alberta)* compared different approaches for estimating snow cover for the entire basin. He said that although estimates can be provided from satellite imagery, there were still difficulties in obtaining data on cloudy days.

At the final workshop, an impact study of the warm summer of 1992 in northern Germany was presented by *Toth (Potsdam Institute of Climate Impacts, Germany)*. New multinational initiatives from the International Arctic Science Committee (IASC) were described for two regions: the Barents Sea (*Lange and Kuhry, University of Muenster, Germany, and IASC Global Change Programme Office, Finland),* and the Bering Sea (*Weller, University of Alaska-Fairbanks, United States).* The full report includes descriptions of the new IASC projects.

2.5 Expectations and Results

After six years of work, it is useful to reflect on the study's expectations and how well they were met. Table 2 compares some expectations and results.

Table 2. Some expectations (1990) and Results (1996)

	EXPECTATIONS	RESULTS
Study objective	Define regional effects of climate change scenarios	Effects defined; some surprises and gaps
Overall research framework	Multidisciplinary, integrated	Many disciplines; partial integration
Role of stakeholders	Partners in planning and research	Some successes, some missed opportunities
Study product - recommendations for research	Identify sensitivities to climate, linkages between systems, research needs	Sensitivities and linkages identified; difficulties in co-ordinating projects and funding studies of traditional knowledge
Study product - recommendations for policy	Identify implications for policy	New questions on adaptation

It is also useful to compare MBIS research results with hypotheses set out by the scientists at the outset of the study. This comparison is provided in Table 3. This comparison shows that while some of the expectations and hypotheses were confirmed, the research provided some surprises.

Table 3. Summary of "What if?" hypotheses from 1990 and results from 1996

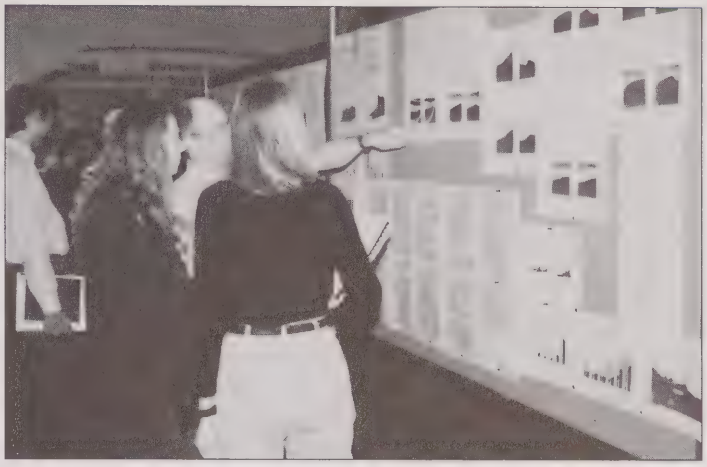
	HYPOTHESES	RESULTS
Water	More water, higher lake and river levels, less ice	Less water, lower minimum levels in fall and winter
Permafrost	Thaw and landslides; northward progression	Landslide problem is site specific and not restricted to discontinuous zone
Forests	Tree line moves north; more fires, faster growth	Forest growth improves only for hardwoods; overall age and yields decline
Wage economy	Improved agriculture; some new opportunities for the wage economy	Mixed effect on wage economy; greater uncertainty for planning of infrastructure.
Aboriginal lifestyles	No clear hypothesis	Effect on communities are mixed; new questions for stakeholders.

3. ROUND TABLE DISCUSSIONS: STAKEHOLDERS' RESPONSES

There were six round table discussions at the MBIS Final Workshop. Stakeholders were asked whether or not the scenario of changes and effects which might occur if the climate changed would make a difference to their visions of the future, and if so, how should the region respond? The discussions were anchored by the five themes:

- Interjurisdictional water management;
- Sustainability of ecosystems
- Economic development;
- Maintenance of infrastructure;
- Sustainability of native lifestyles.

There was a sixth round table at which participants discussed recommendations. All round table sessions included presentations and discussions by stakeholders who sat at the table as well as questions and discussions from scientists who sat in the audience.



Poster Session at MBIS Final Workshop. (Photo by I. Hartley)

3.1 Interjurisdictional Water Management

In the research section a number of changes in rivers, lakes, deltas and wetlands were described for climate change scenarios in the Mackenzie Basin. These changes included:

- Reductions in annual runoff for the basin as a whole;
- Drier conditions in the Peace-Athabasca Delta, with fluctuations from year to year;
- Lower minimum lake levels and river flows which would affect navigation, wildlife habitat, and hydro-electric power production;
- Changes in river and lake ice which would affect winter transportation and spring flooding;
- An increase in the thawing of permafrost which would result in more landslides in areas with a great deal of ground ice, and more sediments in the water because of the landslides.

Most of the round table panelists cited recent examples of significant changes in regional water resources which confirmed part of the science. The examples included:

- Glaciers at the head of the Arctic Red River retreated between 1948 and 1986. It has not been determined what caused the retreat but it follows the general trend of glacial retreat observed elsewhere along the western cordillera of Canada.
- Water levels in Great Slave Lake were one metre or three to four feet lower in 1994/95.
- Water levels and flow conditions in the Mackenzie River region in 1994/95 reached the bottom of the natural 60-year cycle of highs and lows.
- Mills Lake, west of Great Slave Lake, is drying out. At one point, it was invaded by willows which had to be burned so that waterfowl could continue to use the lake.
- Warmer temperatures have shortened the tourist season. The reason is that by August the water levels and water flows in the rivers, which are the areas' natural roads, are so low in some places that tourists cannot use boats to get to where they want to go.
- Grayling, a salmon-like game fish which lives in fresh water and which were once plentiful in the region, are now difficult to find.
- An 11 per cent surcharge has been added to local electricity bills because there was not enough water to meet the demand for hydro-electric power, so utility companies switched to more costly thermal generation.

People in the Northwest Territories have always been concerned about signs of change in the rivers. At first, officials thought the Bennett Dam on the Peace River in British Columbia, and the pulp mills and oil sands project in Alberta were the cause of lower water levels in the Mackenzie River. But *Robert McLeod of NWT Renewable Resources* reported that according to the Northern River Basins Study, climate change has also played a role, exacerbating the considerable effect which the Bennett Dam has had on the river system.

Dean Arey of the Inuvialuit Game Council told the meeting that the rate of climate change would play a major role in determining how his people adapted. About 70 to 80 per cent of the Inuvialuit people lived off the land and relied on fish, whale, and caribou for food and trade. If the changes occurred over centuries then his people would be able to adapt. Changes of nature have always been slow and the Inuvialuit have been able to alter their lifestyles, he said. But, if the changes occurred within a few decades, the Inuvialuit would be hard hit.

Karen LeGresley Hamre of the Gwich'in Interim Land Use Planning Board said that a stable climate was no longer a given for the people of the north. Plants, animals and fish would not stay the same. This was another "big, variable element" which would be introduced into planning aboriginal settlement areas. It would make planning difficult for the permanent blocks of land that were set aside within the land claim area for traditional use. A change in climate might make this land unsuitable for those activities.

Brian O'Donnell of Environment Canada asked what plans the participants could make in the event that the low water levels continued. Would the scenarios of climate change make a difference in how water was managed across the jurisdictions? He answered his own questions by suggesting that the Mackenzie River Basin Transboundary Waters Master Agreement might provide a model for inter-jurisdictional water management.

The agreement defines general water management principles for six jurisdictions including Canada, the NWT, Yukon, B.C., Alberta and Saskatchewan. Under the agreement water is shared in an equitable manner and the aquatic ecosystem is protected. *Terry Zdan of Alberta Environmental Protection* agreed, adding that this is similar to arrangements south of the basin.

3.2 Sustainability of Ecosystems

Section two describes a number of projected changes to vegetation and wildlife in the Mackenzie Basin including;

- Peatlands are expected to dry up in the southern half of the basin, and expand in the northern half;
- The number and severity of fires in the area would increase and if fire management practices did not change, then the average area burned each year would double;
- The number of insects of a pestilent nature would increase, putting forests at risk;
- Forest growth would improve for hardwoods and decline for softwoods;
- The response of fur-bearing animals such as marten, lynx and red fox to forest fires varies with some staying away from burned areas for several years;
- Although there are still many unknowns, the habitats of freshwater fish may change as water temperatures increase;
- Bathurst caribou population would decline in part because the deeper snow would make finding food more difficult in the winter, and in part because the warmer summers would increase the numbers of insects which harass the caribou.

Stewart Cohen introduces the Round Table discussion on sustainability of ecosystems. From left to right the panellists are: George Low, George Kurszewski, Ted Elliot of Colorado State University, Charlie Snowshoe, Cam McGregor, Kevin McCormick and Ron Graf. Maurice Boucher is hidden behind Dr. Cohen. (Photo by I. Hartley)

Round table panelists added their own observations about the effects of the recent warming trend. *George Low of the Department of Fisheries & Oceans* reported that high water temperatures in Beaver Lake and areas downstream from Great Slave Lake had killed a large number of fish in 1989. As a result, the government had limited the number of fish which could be caught and possessed. *George Kurszewski of the Metis Nation* described a decline in the rabbit population in the South Slave region, south of Great Slave Lake. And *Charlie Snowshoe of Fort McPherson* said that after forest fires, trees did not grow as they once had.

Ron Graf of NWT Renewable Resources and *Kevin McCormick of Environment Canada* suggested some scenarios of changes to wildlife. For example, changes in vegetation could force caribou about to give birth to move to areas where vegetation was more plentiful but so were their natural predators.

Panelists agreed that it was sometimes difficult to separate the effects of a change in climate from changes caused by other factors or from natural variations within ecosystems. This difficulty could be further complicated by conditions which produced a response that was not projected or anticipated. For example, contaminants found in water and fish could affect their response to climate change.

The sustainability of the ecosystem also emerged as an important theme during discussions about economic development and native lifestyles. *Maurice Boucher of Fort Resolution's environmental working committee* stressed the need to recognize the role that values and value judgments played in decision making, while *Cam McGregor of Alberta Environmental Protection and Mr. McCormick* suggested that the public's awareness of what the problems and choices were would affect communication between science and policy departments.

The discussion about what steps participants could take to adapt to climate change and to protect the ecosystem included the need to improve communications between scientists and stakeholders, a better understanding of the information requirements of the people who made decisions and a greater appreciation of traditional knowledge. Other proposals were:

- Increase the monitoring of the ecosystem using a partnership of scientists and residents from aboriginal communities to do so. Such a monitoring system could incorporate western science and traditional knowledge
- Expand the use of co-management bodies which include representatives from aboriginal organizations and all levels of government. This would help to ensure that all information would be used when decisions were being made.
- Adopt strategies which would help residents adapt to climate change. Such strategies might include adjusting commercial quotas and catch limits to take into consideration the potential for new species to emerge that might be better suited to changing habitats.
- Continue with settlement of land claims, which would ensure local control, and sustainable levels of trapping, hunting and harvesting of trees.

Climate change is a complex issue that requires a local as well as national and international responses. Although land claim agreements had given aboriginal people more local control than they have had for decades, *Mr. Snowshoe* said even those agreements might not be enough for Northerners to respond effectively to global issues such as climate change, ozone depletion and nuclear accidents like Chernobyl. He said this situation was similar to many of the other issues Northerners faced in that it too involved a learning process for everyone.

3.3 Economic Development

Round table panelists stressed two points. The first was that even if the ball game changed in the future, the old rules of supply and demand would still apply. The second point was that aboriginal land claims had changed the political landscape. Now regional stakeholders had an equal voice with business leaders and scientists in decisions about research and development.

Although panelists had trouble putting a price tag on the possible effects of a change in climate, information gleaned from research gave a clue to what the cost might be.

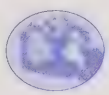
The forest industry - The number of fires would increase which, in turn, would reduce yields, particularly of softwoods.

The tourist industry - The effect would be mixed. A change in climate might reduce business for operators of hunting camps but improve it for water-based recreation in Nahanni National Park.

The agricultural industry - Farmers could benefit from a longer growing season for wheat. On the other hand, they may have to put in irrigation systems to make up for drier soil conditions.

Mining, oil and gas industries - A change in the condition of permafrost and sea ice could increase the cost of land-based operations. But a longer shipping season in the Beaufort Sea could make a seasonal tanker operation financially viable. Further, a longer shipping season might result in an expansion of fossil fuel operations there, which in turn, might increase the opportunities for short-term employment and improve the royalties paid to local communities. The long-term effect of an expanded shipping season could not be determined.

The round-table discussions ranged over a wide number of subjects including:



Business management practices - Industries rarely consider climate change in their day-to-day operations or short-term planning, but it should be added as another element in models used for long-term planning, *Daryll Hebert of Alberta Pacific Forest Industries, Inc.* told round-table participants. Climate change should also be added to the research program at the new national centre of excellence in sustainable forest management at the University of Alberta.

Chris Fletcher of British Columbia's Ministry of Forests said local stakeholders in forestry have not been concerned about climate change, so they have not factored it into forestry policies. *Mr. Hebert* said there was a need to make climate change an element in the models which companies used to analyze how much of the forest to cut and future risks. He was responding to questions about incorporating uncertainty about climate change into resource development decisions — e.g. why is the uncertainty about climate change different from other uncertainties.

Community response - At the community level, participants said partnerships would be needed between communities and higher levels of government to develop management plans. *Bridgette Larocque of the Metis Nation* and *Charlie Furlong, the mayor of Aklavik* reminded participants that land claim settlements had made aboriginal people major landowners in the north. Any plans for economic development and scientific research would require full consultations with aboriginal communities.

As an owner of a small business, *Mr. Furlong* said he had no resources to invest in something as uncertain as climate change. But he realized what the thawing of the permafrost and continued low water levels might mean to his community. Long term monitoring as well as the frequent and timely exchange of information would help communities to adapt to climate change, he said.

Greenhouse gases - With conservation programs and energy efficiency measures, greenhouse gas emissions could be reduced in the Northwest Territories, said *Joe Ahmad of the Northwest Territories Energy Mines and Petroleum Resources*. Although the region's reductions would be modest, they would also be important as a model for others to follow.

Economic sustainability - *Mr. Hebert* said that because business managers measured economic success by demand-driven production, introducing the concept of sustainability into their thinking and into the marketplace would be a tough sell.

3.4 Maintenance of Infrastructure

The panellists at this round table collectively had several decades of experience planning, designing, building and maintaining transportation routes and building structures in permafrost areas within the Mackenzie River Basin. These professionals had witnessed the effects of recent climate trends. Environmental, economic and social considerations were addressed during the discussions about managing infrastructure in the north.

Research suggested the following changes could occur:

- Thawing permafrost could increase uncertainty and risk for buildings, pipelines, roads and other infrastructure. The communities at risk include Norman Wells, Arctic Red River, Tuktoyaktuk, Fort McPherson and Fort Good Hope
- Reductions in ice cover and earlier snowmelt would shorten the winter road season
- An increase in the frequency of forest fires would increase fire risk throughout the region
- Lower minimum water levels could create problems for shipping along rivers and lakes.

Rod Dobell of the University of Victoria suggested the group expand the notion of infrastructure to include education and insurance mechanisms as well as emergency response, monitoring, regulatory, health and social support systems. Infrastructure could be the social and cultural institutions which pool risks and support people in times of stress and change. Infrastructure could also be the institutions which govern harvesting and land use activities in a sustainable manner. Some responses to climate change might include changing design and construction standards, changing the type of animals, fishes and trees which are hunted, trapped, fished and cut by the forestry, fisheries or wildlife industries and regulatory reforms governing land use.

Pietro de Bastiani of the NWT Ministry of Transportation described potential effects which climate change could have on marine, rail and road transportation. For example, mobile sea ice is a barrier to shipping and warming may result in increasing the number of ice breakers needed during the winter. This has obvious implications for shipping in the Arctic. Farther south, the Mackenzie River is one of the main routes used to supply northern communities and industries with fuel and other basic goods. Barges and tugs depend on high water conditions. Lower stream flows could result in higher transportation costs.

Permafrost and ice conditions are important for all land-based transportation. Ice strips for air transport are eroding in areas affected by fires. Permanent roads and ferry harbours are being damaged by erosion caused by melting permafrost. Any changes in the rates of run-off, melting and water flows would result in revising dates for cut-offs and closures of winter roads. The development of new roads to new mines would need to be carefully assessed.

Randy Cleveland of NWT Ministry of Public Works & Services, said that construction techniques had been developed to deal with the cold of the north, and to a large degree, required the cold to work properly. The techniques were sensitive to changes in ground temperature and would have to be adapted to fit warmer surface temperatures.

Alan Hanna of AGRA Earth & Environmental Limited participated on the panel as an engineer who had worked on pipelines in the north and in Russia. He felt that in the short term the effect of climate change would not be significant but that it could be in the long term. In general, he said bed rock would not be affected by climate change but areas with a great deal of ice would be. Discontinuous permafrost zones would be altered, and in some places greatly, while the continuous permafrost zones would get off lightly. More fires would probably increase mud flows. Dams and dikes might have to be monitored and retrofitted with insulation or artificial means of cooling the ground, and large pipelines might have to be chilled to reduce their effect on right of ways. He was confident that the engineering industry could deal with warm and cold permafrost.

He told study participants not to get alarmed about ruptures in pipelines and potential extreme events. Temperature swings were variable, and people in the north should adapt, not overreact. He also said that it would be less expensive to remedy the situation when it happened rather than to invest in large capital expenditures now.

Mr. Cleveland said developers considered changes in water level, stability of slopes and the speed of erosion along the coast when looking for places to build. As long as the warming occurred slowly, the construction industry could adapt. But adaptation was not just a question of engineering. New technologies and construction techniques probably would mean higher costs and more imported materials and labour. The "ecological footprint" from construction in the north is already large. What is needed is "sustainable construction" or construction which uses local instead of imported materials and is compatible with the ecosystem and aboriginal lifestyles in the north.

Technology would change, but this alone would not mitigate the problem of global warming. Appropriate building technology would develop, and demonstration projects should be advocated. The government of the NWT is now looking at sustainable construction.

Several questions related to sustainability were raised by the audience including the use of alternative energy in energy systems, consideration of climate change in long-term design standards, and the possibility of the north's ecological footprint getting larger.

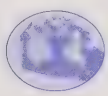
Panellists said that alternative sources of energy from wind and passive solar technology were being considered as was the use of waste heat from industry. Energy conservation programs were being implemented. Further, governments were reconsidering design standards, since current standards were based on past experience and climate change introduced a new complexity. However, new information on sea ice was not used because of downsizing and closing of various services, and rising demand for all-weather roads and other infrastructure was increasing the cost of construction and the size of the north's ecological footprint.

3.5 Sustainability of Native Lifestyles

Climate change joins a long list of factors which affect the lifestyle and livelihoods of the people who live in the north, said *Joanne Barnaby of the Dene Cultural Institute*. The traditional way of life largely depends on fishing, hunting, and trapping, and any change, including climate change, which affects these natural resources will also affect people's livelihood. Another factor, she said, is the growing number of native people who are joining the wage-based economy. This trend coupled with an increasing reliance on imported goods may decrease the reliance of native people on the local resources. With or without climate change, she said, native lifestyles are in flux and the effect which a changing climate might have should be considered in this context.

3.5.1 Changes seen

Local residents said that there had been a slight, but noticeable shift in the length and transition between seasons. *Don Antoine of the Dene Environmental Committee, Fort Simpson, NWT,* said that freeze-up starts later and ice breakup starts earlier and is less violent than in the past. He suggested that perhaps this is a consequence of thinner ice and a more gradual transition between seasons.



Water levels across the Mackenzie Basin are also at an all time low, possibly because there is less precipitation and more water lost through evaporation. Recent climate warming is believed to be the cause of the low water levels. *Whit Fraser of the Canadian Polar Commission* suggested that lower water levels may be the reason there are no muskrat today in the Peace-Athabasca delta and that trapping is not the major industry there that it was a few decades ago.

3.5.2 Expected changes and their effect on local communities

The coastal communities of Tuktoyaktuk and Inuvik are expected to be at risk of flooding if a projected sea level rise occurs. Given sufficient warning and time to change, communities will be able to move. The cost of doing so, however, will be more than the community can afford.

An increase in the frequency and intensity of forest fires can significantly reduce the variety and number of wildlife living in traditional hunting and trapping grounds. *Lou Comin of Wood Buffalo National Park* said that some animals such as martin, fisher or squirrel thrive in mature forests, so they may not return to burned areas. Caribou may react the same way. There is great uncertainty about the ability of particular species to adapt to changes in fire and the effect is expected to vary from species to species.

3.5.3 Effect on the two economies - traditional and wage-based

The availability of wildlife is important to many native communities. It is a source of food, income and traditional clothing. Equally important, wildlife is critical for maintaining traditional systems of knowledge and identity. If there are significant changes in wildlife numbers or habitats, then members of native communities will have to modify traditional patterns of trapping, fishing, and hunting.

Native people have adapted to change many times in the past, but it was the predictability of the extent, duration and speed of changes which made that possible. Participants at the round table said that native communities will be at risk if changes affecting wildlife are fast, dramatic and unpredictable.

The effect of climate change on jobs in the area is expected to be mixed. The employment picture has changed greatly in recent decades and continues to change — for three reasons. First, according to *Herbert Felix of the Inuvialuit Game Council*, children are better educated today than their parents and grandparents. Second, access to local communities has improved, and in some cases, there is regular air service which some people use to commute to their jobs. Third, in areas where wildlife has disappeared, some native people have opted for jobs which pay wages. If climate change reduces the chances of native people living by traditional means, then that lifestyle which has endured for centuries will eventually disappear.

3.5.4 Response to climate change

On partnerships - Participants talked about building more effective partnerships between the various levels of government and native communities. For example, panelists agreed that the scientific and native communities should collaborate and integrate western science with the traditional knowledge of native people. *Mr. Antoine* said that the collection of information should not be seen as the end of the process. This knowledge should be used in modern management practices as well as in traditional activities: for scientists and resource managers, that would mean respecting the wisdom of traditional knowledge; for government officials, that would mean bringing native people into the decision-making process early in the day; and for the elders and young people of native communities, that would mean spending more time with each other.

On monitoring - Panelists said that information on wildlife, water, vegetation, landforms, weather, harvest rates, social conditions, employment, and other factors should be collected and used to establish a baseline for future monitoring. *Mr. Felix* said the baseline information is necessary to discover which resources and values are at risk and need protection.

Monitoring should be a collaborative effort, using scientific methods and instruments as well as the information and knowledge of people on the land. Traditional aboriginal knowledge is based on the experience of many generations and has a historical perspective that scientific management methods lack. *Ms Barnaby* and *Mr. Antoine* said that native people are more than willing to share this knowledge. They are the ones on the land who will see the changes first and be directly affected by them.

On greenhouse gas emissions - Finally, participants agreed that the people in the North have to take responsibility for reducing emissions of greenhouse gases which they produce. *Mr.Comin* pointed out that without preventive action the situation will get worse. Such action should include educating local people about the problem and building on their creativity and ability to adapt. Results of the study should also be used to educate industry and government about the existing and potential costs and effects of climate change for the land and people in the North.

3.5.5 Strategies for adapting

Local communities must help to develop and put into place any strategies to adapt to climate change. *Mr. Antoine* cited the Community Resource Management Projects as an example of a workable strategy which involves all the players. In this case, hunters and trappers work together on an integrated management framework. This co-operation is important. Some strategies may involve cutting back on hunting and trapping or cancelling plans for commercial expansion in order to save a species endangered by climate change.

Adapting to climate change will also require training programs so that there will be people with leadership and management skills. For example, *Mr. Antoine* said, when Nunavut, comes into existence in 1999, it will require well-trained people. (In 1999, the NWT will be divided into two territories, Nunavut in the east and an as yet unnamed territory in the west.) More training programs, such as the one on renewable resource management for aboriginal youth offered by the Aurora Research Institute in Inuvik, will be necessary to prepare for the tasks ahead.

3.6 Recommendations

The need for collaboration as well as for better communication, continued monitoring and increased use of traditional knowledge dominated the discussion.

Communication - Participants pointed out that there was a great need to communicate in plain language. Information that was not clearly stated would be ignored.

Scientists were also encouraged to speak out strongly, to limit their use of the terms "may" and "could". Many decisions made by policy makers in other areas were not based on a 100 per cent certainty. Scientists should not be held hostage to the ideal of absolute certainty. The messages should aim to "make decision-makers decide to make decisions now". *Rodney White of the University of Toronto* added that scenarios should be developed for more than a doubling of greenhouse gas concentrations in the air.

Collaboration - Participants suggested contacting the Canadian Climate Program, Canadian Global Change Program and the Canadian Polar Commission and asking these organizations to help get the message out and to lobby on behalf of the Northerners. *Jim Bruce of the Canadian Global Change Program* also suggested that MBIS provide his organization and the Canada Country Study on Climate Impacts and Adaptation with information about the study. He said scientists and stakeholders who worked on MBIS should also participate in climate change studies in neighbouring regions and that climate change should be considered in the new Mackenzie Basin Transboundary Waters Agreement.

David Malcolm of the Aurora Research Institute suggested that existing institutions in the region could assist in co-ordinating future efforts.

Monitoring - *Mr. Bruce* also suggested that monitoring of the Mackenzie Basin continue but that it include empirical and traditional knowledge. Participants also suggested that researchers send the data collected over the course of the study to archives for future use. A number of significant climate-related changes were found by MBIS researchers and the proposed monitoring system would help track changes as they continued. This region was cited as a bellwether of climate change for Canada.

Traditional knowledge - The aboriginal community is planning to develop standards for traditional knowledge-based data. For their part, scientists need to develop a framework for using traditional knowledge in scientific work. The advantage of traditional knowledge is that it can provide information about changes for smaller areas than most models. Further, traditional knowledge also points out what problems are of great concern to the stakeholders.

Joe Benoit of the Gwich'in Land Administration reminded researchers that traditional knowledge exists because lives depend on it. They were encouraged to do research as if their lives depended on it.

Integrated assessment - Participants said that multi-disciplinary projects such as the MBIS needed a common platform for data and a small office in the study area, with full-time staff to help scientists and stakeholders exchange information. For the benefit of other studies of this nature, participants suggested that the study's leaders publish a paper on the lessons learned from the integration process, including the role of stakeholders.

There were a number of suggestions on the future of this research including incorporating the research into studies of the Arctic as a whole and expanding the research into an integrated study of other stresses in the region, such as ozone depletion. Further, with budget cutbacks, participants said that future studies in the region would probably be driven by the needs of stakeholders and focused more closely on their concerns such as wildlife, ground water, water quality and forest fire management.

The discussions about climate change are approaching an interesting phase. In October 1997, Canada and about 160 countries will try to agree on the next steps to take to deal with climate change.

Results of the Mackenzie Basin Impact Study suggest that the effects of recent climate warming are evident in the region. Even though the basin's residents contribute only a small portion of Canada's greenhouse gas emissions they will probably live through some quite dramatic changes because of future warming. Nevertheless, residents believe they will be able to adapt to these changes — if they do not happen quickly. Slowing the pace of climate change should be a goal of Canada's policies.

Acknowledgments

MBIS provided full or partial funding for 19 projects during 1991-1996. Another 11 research activities were contributed in-kind to MBIS through Environment Canada, BC Hydro and the University of Victoria. Various data sets were provided by federal, provincial and territorial government agencies. Total research expenditures were $770,000 (see Table 1), with an additional $180,000 provided for publications, travel support and other administrative work.

The Canadian government was the principal sponsor of the study. Esso Resources Ltd. also provided direct funding to MBIS for research and other activities. Many investigators obtained additional financial and in-kind support from other sources, which are not included in the above totals. In-kind contributions of data and research were probably of equal value to directly sponsored activities.

MBIS was directed by a Working Committee consisting of representatives from federal, provincial and territorial government agencies, aboriginal organizations and the private sector (see Table 4). The Working Committee reviewed and ranked research proposals for funding support, and provided advice on matters related to research and consultation. Most of the committee's work took place during 1990-1994.

Table 4. MBIS Interagency Working Committee

FEDERAL	PROV./TERR.	PRIVATE SECTOR	ABORIGINAL
Agriculture	Alberta Env. Protection	Esso Resources Ltd.	Dene Nation
Environment	Alberta Research Council		Gwich'in Tribal Council
Fisheries & Oceans	British Columbia Hydro		Indian Assoc. of Alberta
Indian & Northern Affairs	NWT Energy, Mines & Petroleum Resources		Inuvialuit Game Council
National Defense	NWT Renewable Resources		Metis Association of NWT
Natural Resources (former Energy, Mines & Resources, and Forestry)	Yukon Territory Renewable Resources		
Tourism			

Source: Modified from MBIS Interim Report #1 (1993).

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